

# PATENT SPECIFICATION

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## DRAWINGS ATTACHED

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## (54) APPARATUS FOR MEASURING THE SURFACE CONFIGURATION OF AT LEAST PART OF A BODY

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an apparatus for measuring the surface configuration of at least part of a body, which apparatus comprises a curved support capable of at least partially surrounding the body, and a carriage movable along the support, which carriage carries a sensing probe which is movable in a direction towards and away from the body.

Such an apparatus is described in "Physikalische und technische Grundlagen der Betrahlungsplanung" by S. Matschke *et al.*, Leipzig 1968, pages 217 and 218. In the apparatus for measuring patients described in this book, a body girth of a patient is measured by moving a sensing probe, which may terminate, for example, in a ball, over the body with a given pressure. A pen secured to the sensing probe records the body girth. When the body girth of a patient is measured for therapeutic purposes this method may be painful. Furthermore, the sliding or rolling contact between the sensing probe and the body limits the measuring rate. When a patient's girth is being measured, both the hurtful contact and the comparatively long duration of the measurement increase the likelihood of measuring errors due to movements of the patient during the measuring process.

It is an object of the invention to obviate the said disadvantages and for this purpose an apparatus of the type mentioned at the beginning of this specification is characterized in that it further comprises positioning

means for automatically adjusting the position of the sensing probe during movement of the carriage along the curved support so as to maintain a fixed distance between the probe and the surface of the body; the sensing probe being provided with a source of radiation, a radiation guide, and a device for detecting radiation reflected from the surface of the body to be measured, radiation which emerges from the radiation guide causing the detection device to produce a detection signal whose value depends upon the spacing between the sensing probe and the surface of the body.

Since in the apparatus according to the invention the sensing probe follows the body outline without physical contact therewith, no pain is caused to the patients and measurements may be made at a fast rate. As a result, the likelihood of measuring errors due to body movements during measuring is greatly reduced.

To prevent the use of a mechanical writing device for recording the body outline from restricting the measuring rate, in a preferred embodiment of the invention this device is replaced by an electronic arrangement.

A preferred embodiment of an apparatus according to the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawing, in which:

Fig. 1 shows schematically a preferred embodiment using a circular support, and

Fig. 2 shows schematically that end of a sensing probe with optical means for automatic adjustment of the position thereof in relation to the surface of the body.

The apparatus shown in Fig. 1 comprises a circular support 1. Depending upon the shape of the objects to be measured the support may alternatively be, for example, elliptical. Furthermore, for certain uses a sup-

port curved through 180° only may suffice. For measuring the entire surface of an object the support may be given the form of a helical coil which extends at least through-  
 5 out the length of the object. A carriage 2 is movable along the support 1 around the entire, or substantially the entire, circumference thereof. The carriage carries a rod-shaped sensing probe 3, a servo-motor 4,  
 10 electric contacts, not shown, for the supply of currents for moving the carriage and for energising the servo-motor, and contacts from which electric signals may be taken. The contacts may be sliding contacts for electric  
 15 conductors extending in the carrier 1. The sensing probe 3 is radially movable by actuating the servo-motor 4. The servo-motor is controlled by an adjusting mechanism which is mounted in an end 6 of the sensing probe  
 20 facing a body 5 the surface configuration of which is to be measured. The end 6 of the sensing probe 3 is shown enlarged in Fig. 2. The sensing probe includes a radiation guide 7 which preferably comprises a bundle  
 25 of optical fibres. At one end 8 the radiation guide is obliquely directed to a point aligned with a cylindrical recess 9 in the sensing probe. A bottom part 10 of the recess 9 carries two radiation detectors 11 and 12 which  
 30 are mounted one behind the other with respect to the radiation guide 7. The two radiation detectors receive radiation which is emitted by a radiation source 13, guided by the radiation  
 35 guide to the surface of the body and is reflected from the body surface, equality between the radiation portions received by each detector being achieved only at a given spacing between the sensing probe 3 and the  
 40 surface of body 5, which spacing is determined by the geometry of the radiation guide 7 and the recess 9. When the spacing between the sensing probe and the surface of the body is greater or smaller than the said given  
 45 spacing the detectors receive different amounts of radiation. In the arrangement shown schematically in Fig. 2 the detector 11 receives the greater part of the radiation when the spacing is greater, and the detector 12  
 50 receives the greater part when the spacing is smaller, than the said given spacing. A sensitive detection signal as a function of the spacing between the sensing probe and the surface of the body is obtainable from a signal  
 55 which is the difference of the signals of the two detectors. This difference signal controls the servo-motor 4 and thus ensures automatic adjustment of the sensing probe to a predetermined constant spacing between the sensing probe and the surface of the  
 60 body.

A layer of radiation-absorbing material 15 with which the cylindrical surface 14 of the recess 9 is coated prevents radiation from reaching the detectors by reflection at this  
 65 surface. To avoid stray light, boundary sur-

faces 16 of the sensing probe which face the body to be measured may also be coated with the absorbing layer. The radiation detector may use simple photocells. By select-  
 70 ing detectors having a sensitivity outside the range of visible light, for example ultraviolet-sensitive detectors, and by adapting the radiation source 13 to this sensitivity, the mechanism for adjusting the sensing probe may  
 75 simply be rendered insensitive to ambient light. This screening may be optimised by using detectors having a narrow range of spectral sensitivity and a radiation source adapted to this narrow range. The term "radiation" is used herein in a wide sense. It may  
 80 include short-wave radiation and X-rays. Any radiation may be used which is sufficiently reflected from the surface of the object and is not adversely affected by it.

If a sensing probe of the described construction strikes the body surface, the detectors do not receive radiation and hence supply no signal for the servo-motor. To ensure  
 85 that in this case a force repelling the sensing probe from the body surface is produced, a circuit element 18 responsive to mechanical stress is provided at a tip 17 of the sensing probe. This element 18 may, for  
 90 example, be a plate of a piezo-electric material or a micro-switch.

The apparatus according to the invention enables body outlines to be measured at a faster rate than is possible with any known  
 95 apparatus. Although the restriction imposed by the physical contact with the body to be measured has been removed, the measuring rate might still be limited by the mechanical recording of the body outline. In a preferred  
 100 embodiment of the apparatus according to the invention mechanical recording is replaced by electronic recording. This also simplifies further processing of the measuring data. In the case of a circular support the position of the sensing probe in polar coordinates is determined  
 105 by an angle  $\alpha$  measured along the support and by a radius  $r$  measured from the geometric centre 19 of the support. Both quantities are expressed in the form of electric signals during the measurement. The constant spacing 20 between the surface of the body and the sensing probe may simply  
 110 be allowed for. Once the electric measuring signals have become available they may simultaneously be applied to a recorder and, by means of an analogue-digital converter, to a  
 115 computer. In the computer the measuring data may be used, for example, to compute the optimum irradiation dose for a patient. The results may also be written in a store, for example, a punched card associated with  
 120 a patient.

Although an apparatus of this type will mainly be used in measuring the body outlines of patients for therapeutic purposes, the field of application is not restricted to this  
 130

use. An example of another use is measuring a piece of stone. From the measuring results the computer may then determine the optimum manner of cutting at least one stone having a prescribed shape and/or size from the original piece. The data from the computer may be used to control a suitable programmed device for cutting the stone. The support for the sensing probe may in this case appropriately take the form of a helical coil encircling the entire stone.

#### WHAT WE CLAIM IS:—

1. Apparatus for measuring the surface configuration of at least part of a body, comprising a curved support capable of at least partially surrounding the body, and a carriage movable along this support, which carriage carries a sensing probe which is movable in a direction towards and away from the body positioning means for automatically adjusting the position of the sensing probe during movement of the carriage along the curved support so as to maintain a fixed distance between the probe and the surface of the body, the sensing probe being provided with a source of radiation, a radiation guide and a device for detecting radiation reflected from the surface of the body to be measured, radiation which emerges from the radiation guide causing the detection device to produce a detection signal which depends upon the spacing between the sensing probe and the surface of the body.

2. Apparatus as claimed in claim 1, characterized in that the support is a circular guide along which the carriage is movable through an angle of at least substantially  $360^\circ$ .

3. Apparatus as claimed in claim 1 or 2, characterized in that the sensing probe includes a servo-mechanism which is in a quiescent condition at a spacing between the surface of the body and the sensing probe, which spacing is determined by the geometry of the radiation guide relative to the detection device.

4. Apparatus as claimed in claim 3, characterized in that an end of the radiation guide is directed to a point aligned with the axis of a cylindrical recess in the sensing probe on the bottom of which two photocells are arranged one behind the other with respect to the radiation guide, a difference signal from the two photocells controlling the servo-mechanism.

5. Apparatus as claimed in any of the preceding claims, characterized in that the sensing probe at its end nearest to the body has a stress-sensitive circuit element which when actuated causes the sensing probe to move away from the body.

6. Apparatus as claimed in claim 5, characterized in that the circuit element comprises a plate of a piezo-electric material.

7. Apparatus as claimed in any of the preceding claims including means for producing electric signals in dependence upon the position of the sensing probe.

8. Apparatus as claimed in any of claims 2 to 7 wherein the said means produces an electric signal representative of the angular position of the sensing probe around the curved support and a further electrical signal dependent upon the distance between the geometric centre of the circular path and the sensing probe.

9. Apparatus as claimed in claim 7 or claim 8, characterized in that the apparatus is associated with an analogue-digital converter and with recording apparatus for processing the electric signals.

10. Apparatus for measuring the surface configuration of at least part of a body substantially as hereinbefore described with reference to the accompanying drawing.

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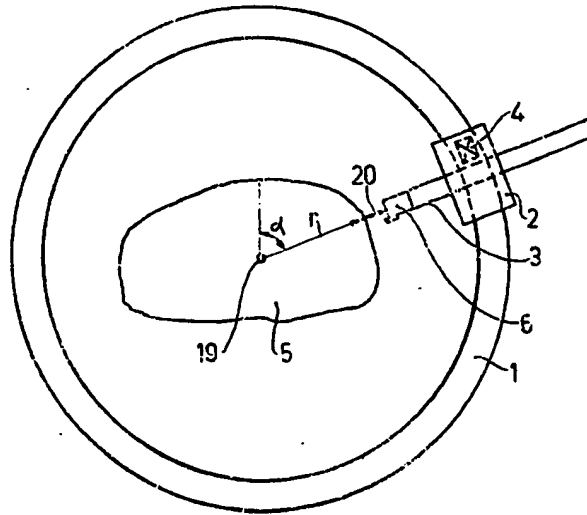


Fig.1

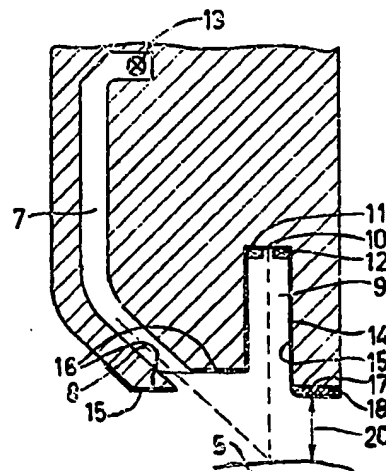


Fig.2